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U. S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES
CORPS OF ENGINEERS

Technical Report 1514-TR

THE VULNERABILITY OF ENGINEER VANS TO CHEMICAL, BIOLOGICAL, AND RADIOLOGICAL WARFARE (U)

Project 8-12-75-001

25 March 1958

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Prepared by

B. J. Ladner
and
W. H. Van Horn
Special Projects Branch
Military Engineering Department
U. S. Army Engineer Research and Development Laboratories
Corps of Engineers
Fort Belvoir, Virginia

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PREFACE

Work on this project was conducted under the authority of Project 8-12-75-001 (S) during the period September 1956 to October 1957.

The investigation was made by 1st Lt. R. G. Evans, Sp-3 J. L. Tucker, Sp-3 F. F. Gross, Sp-3 B. J. Ledner, and W. H. Van Horn. Work was done under the supervision of John G. Lewis, Chief, Technical Analysis Section; Thomas G. Walsh, Chief, Special Projects Branch; and N. K. Dickinson, Chief, Military Engineering Department.

Metronics Associates was most helpful in offering guidance and technical advice in the use of the FP technique.

CONTENTS

SUMMARY

This report investigates the protection offered by various Corps of Engineers van bodies from chemical, biological, or radiological (CBR) attack.

Leakage into the vans was determined by subjecting the vans to an aerosol of zinc-cadmium sulfide. A correlation between simulant leakage and actual CBR agents is drawn.

Pressurization of the vans by use of the ventilating systems and the effects of field expedient sealing were investigated.

The report concludes that:

a. The vans offer little or no protection against newer CW agents and only limited protection against older CW agents.

b. Decontamination of the vans following a CW attack would be necessary to keep damage at a minimum and to remove any hazard to operating personnel.

c. None of the vans offer protection against BW agents.

d. Decontamination of the vans following a BW attack would be necessary to eliminate or reduce the hazard to personnel.

e. The vans offer negligible protection from radiation from fallout outside the vans.

f. Decontamination of the vans following an RW attack would be necessary to remove any inhalation hazard resulting from fallout which might leak into the vans.

g. In the case of fallout, decontamination of the vans in which films are processed would be necessary to protect film stocks.

h. Field expedient sealing is of little value; limited protection against older CW agents, however, can be obtained by its use.

i. The present ventilation system is able to produce significant pressurization of the vans.

j. Minor modification of the ventilation system by the addition of a gas-particulate filter combined with additional sealing around openings will probably provide adequate gas-proofing for the vans.

THE VULNERABILITY OF ENGINEER VANS TO CHEMICAL, BIOLOGICAL, AND RADIOLOGICAL WARFARE (U)

I. INTRODUCTION

1. Subject. This report investigates the protection offered by various Corps of Engineers van bodies from chemical, biological, or radiological (CBR) attack.

2. Background and Previous Investigations. Chemical, biological, or radiological attack upon CE units operating from vans could disrupt operations for considerable lengths of time by contaminating material and supplies as well as creating a continuing hazard to personnel. The effectiveness of the attack is dependent upon the extent of leakage of the toxic agent into the van (radiation excepted), the sensitivity of working supplies to the contaminant, and the ability of personnel to work while wearing protective clothing. A previous report[1] concludes that many of the materials found in Engineer vans are susceptible to contaminants and that operations by protected personnel are generally not feasible. It was therefore concluded that the first factor, the degree of leakage into the vans under various operating conditions, should be determined in order to arrive at a possible means of minimizing the effects of a contaminating attack.

In 1942, the leakage of chemical warfare (CW) agents into then-existent CE vans was crudely determined by placing a smoke grenade in the van and noting smoke leaks from outside. The feasibility of providing vans with an M3 collective protector was investigated; however, the M3 was found to be too bulky and cumbersome to be used as a permanent fixture.

The Chemical Warfare Laboratories, Army Chemical Center, Maryland, has a continuing project (4-80-12-006) on collective protection for military transport vehicles. Investigations have been made on fire control and shop vans, and suitable collective protective devices have been installed[2][3]. The degree of protection required has been categorized as follows:

Category A. Protection required for military transport vehicles in which operations must be maintained and which must be operated by unprotected personnel who require frequent entry or exit.

Category B. Same as Category A except entry or exit is not required.

Category C. Protection required for vehicles in which operations may be suspended temporarily.

Category D. Protection required for vehicles in which operations may be suspended temporarily but in which the contents must be protected from contamination.

An ERDL memo report discussed the vulnerability of CE vans, both operationally and materially, to CBR attack(1). The report concluded that, in general, Category D protection was sufficient, and it was recommended that the degree of protection provided be determined.

II. INVESTIGATION

3. Site and Equipment. Tests utilizing CE vans, fluorescent particle (FP) cloud generation and sampling equipment, and meteorological equipment were conducted by USAERDL personnel.

a. Site. The only site available for the tests was the Northeast corner of Demolitions Range One of the Engineer Proving Ground, Fort Belvoir, Virginia (Fig. 1). This site is an open area of approximately five acres bordered by trees. A small gully runs through the center of the area.

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Fig. 1. An aerial view of the test site showing vehicles in position.

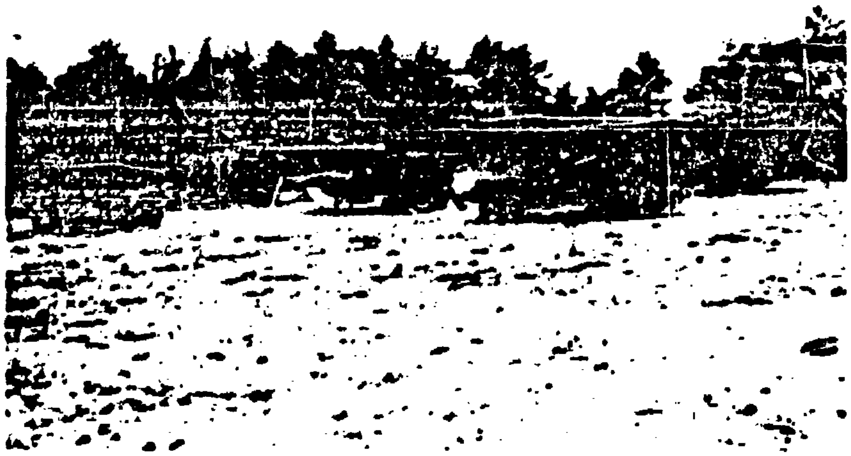

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Fig. 2. (1 to r) Water purification van, expanded engineer expansible van, shop van trailer, map reproduction van, and expanded camera van in position.

b. Vans and Equipment. Used in the tests were prototype Corps of Engineers vans of the following types (Fig. 2):

Water purification van, U.S.A. #41212337, equipped with two gasoline heaters whose blowers can also be used in ventilation.

Camera van, U.S.A. #41112483, equipped with an air conditioning unit (which also serves as a ventilating system) and two gasoline heaters of the same type as those in the water purification van.

Map reproduction van, U.S.A. #41214988, equipped with the same equipment as the camera van.

Engineer expansible van, U.S.A. #41214975, equipped with the same equipment as the camera van.

Semi-trailer shop van, U.S.A. #7A7265, equipped with the same equipment as the camera van.

In general, chemicals used in water purification are stored within the water purification van. Operation of the van could be carried on for a short period of time by a man dressed in impregnated protective clothing, gloves, and protective mask.

When the map, camera, and engineer vans are in operation, it is necessary for personnel to move materials from one van to another. Operations could be suspended for a short period of time during an attack.

c. Fluorescent Particle Cloud Generation and Sampling Equipment. A Metronics Associates, Inc., Model 10 Aerosol Generator (Fig. 3) was used to generate the FP cloud. This aerosol generator consists of two units, the aerosol generator and the control panel. The aerosol generator unit includes motor-blower, nozzle, and drive assembly; angle frame stand with trunnion clamps; and feed mechanism with feed tube (Fig. 4). The control unit has an installed control panel with all necessary power cables (Fig. 5). Electrical power is supplied by an outside 110 v A.C. source.

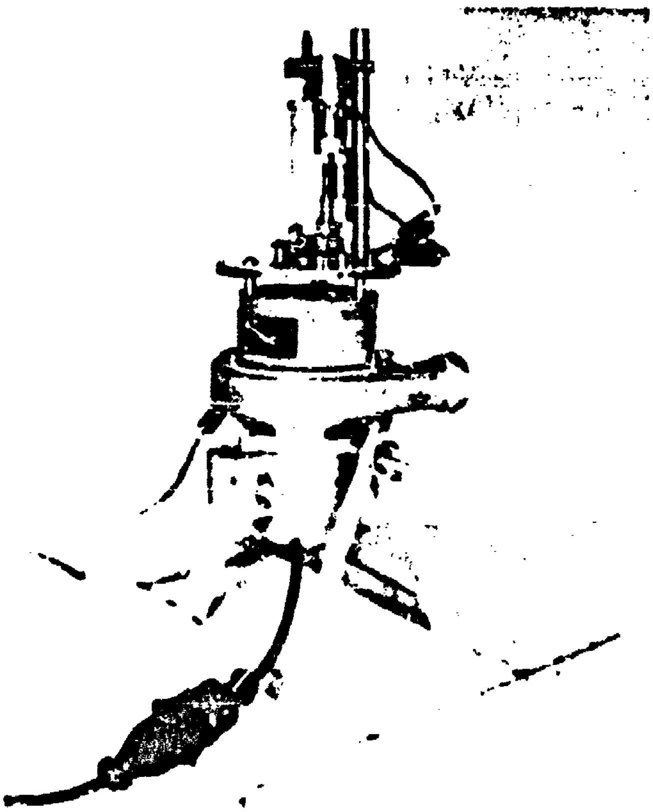

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Fig. 3. The aerosol generator unit with feed mechanism and feed tube attached.

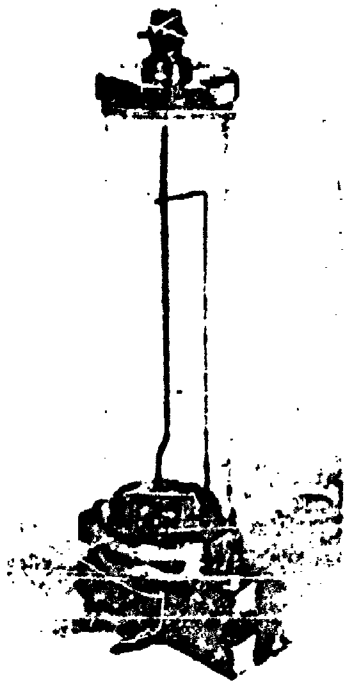

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Fig. 4. Feed mechanism and feed tube.

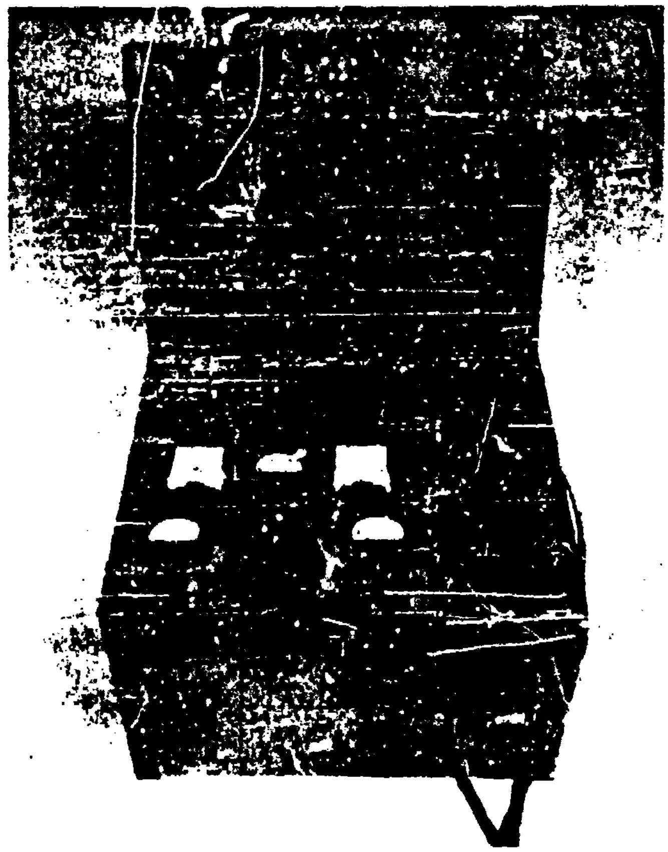

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Fig. 5. The control unit showing power cables attached.

The FP material is discharged by the feed mechanism from the feed tube into the blower as a continual series of increments. The material is entrained and aerosolized by the rapidly accelerating stream of air passing through the blower. The controls can be set for different blower or feed-mechanism speeds to control the amount of FP material aerosolized during any time period.

Sampling equipment included filter holders with critical orifices, which regulated air flow to within 10% of the calibrated volume, machined by Millipore Corporation, rubber covers, Millipore AA Black Plain one-inch filters and pads (Figs. 6 and 7), 1/6-hp Gast Vacuum Pumps, Fischer Scientific Co. laboratory clamps, and 6-feet-high ring stands. Samples were collected by placing the Millipore filters on nutrient pad supports in the filter holders. The filter holders were then attached to the vacuum pumps by means of ¼-inch rubber hose (Fig. 8). As air was drawn through the filters, all FP particles were impinged on the filters. Fluorescent-particle-counting equipment included two model FBV-8 Bausch and Lomb microscopes. This model is equipped with a mechanical stage which

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Fig. 6. Filter holder dismantled. (l to r) Rubber cover, screw-down lid, hold-down ring, filter, nutrient pad support, and filter holder body.

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Fig. 7. Filter holder assembled.

enables the viewer to scan the entire slide, 10- and 21-power objective lenses, and 5-power eyepieces equipped with reticles in the form of squares of known size. Will Corporation Bioloid glass microscope slides were used as mounts for the contaminated filters.

General Electric (Model H-100 BL4) ultraviolet bulbs were mounted in American Optical Company (Model 370) mounts to provide illumination of the microscope and slides. Illumination level was kept constant by use of General Electric (Model H-4) transformers in series with Powerstat (Model 116) variable transformers.

Air pressure changes inside the vans were recorded by use of Statham pressure transducers. These instruments have a

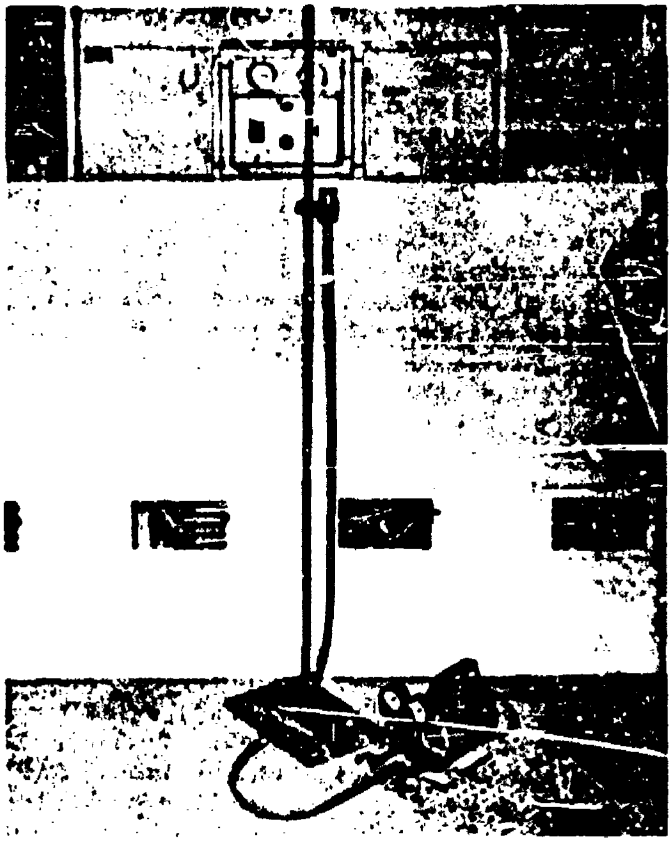

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Fig. 8. Typical sample point showing filter holder, with rubber cover, attached to a vacuum pump.

pressure range of $\pm$ 0.05 psid. Each transducer was connected through a Brush (Model BL-360) "Universal" amplifier to a Brush (Model BL-222) recording oscillograph. This provided a continuous recording of the signal changes caused by variation of the differential pressure at the transducer location.

Each transducer was placed within a van and connected to a static outlet. The outlet was provided by $\frac{1}{4}$-inch aluminum tube inserted through a sealed hole in the van wall and extending out of the van one foot.

Electrical power was supplied for vans, sampling, and meteorological equipment by one 5-kw and one 10-kw generator; power was supplied for the FP generator by a 1-kw generator.

d. Meteorological. Two Bendix-Friez aerovane systems were used to record wind speed and direction. The Model 141 recorder is a 2-element recorder that simultaneously produces inked traces of wind direction and speed in separate channels on a continuous paper chart. Charts may be run at a speed of either 3 inches per minute or 3 inches per hour.

Barometric pressure was recorded by a Bendix-Friez (Model 790-1) microbarograph. A Bendix-Friez (Model 594) Hygro-Thermograph was used to provide a continuous record of free air temperature and relative humidity.

Temperature gradients were recorded by use of a Foxboro Dynalog Differential Temperature Recorder. This unit recorded differences in temperature between pairs of thermistors, one at a height of 6 feet and the other at a height of 1 foot. This system continuously records up to three measurements on one circular chart.

4. Methods. After various methods of testing for leakage were investigated, it was decided to adapt the FP technique using a zinc-cadmium sulfide simulant(4) (5). This technique has been extensively used in meteorological and toxicological studies by the Chemical Corps.

a. Preliminary Runs. Two preliminary runs were made to determine the spread and persistence of the FP material. The first of these runs was to determine the spread of the FP cloud. Six samplers were set 30 feet apart in a straight line. The FP generator was set 200 feet upwind on a line perpendicular to the sampler line and was run for 5 minutes. Samples were collected over a 30-minute period.

As a result of this run, it was found that the spread of an FP cloud which could be expected under test conditions was greater than 150 feet at a distance of 200 feet downwind from the FP generator.

The second of these runs was made to determine the persistence of an FP cloud after the end of generation. Six samplers were set up 1 foot apart. The FP generator was set 200 feet upwind and was run for 5 minutes. The first sampler was turned on at the start of generation. After 5 minutes, the second sampler was turned on and the first was turned off. The third sampler was turned on at the end of 10 minutes, and the second was turned off. This procedure was repeated until each sampler had been run 5 minutes for a total time of 30 minutes. It was found that under test conditions the FP material did not persist for more than five minutes after the end of generation. Results of the preliminary runs are contained in Table I.

Table I. Results of Preliminary Runs

Spread of FP Material*		Persistence of FP Material**	
Sample Point	Raw Count	Sample Point	Raw Count
1	60.9×10^4	1(0-5 min)	3.1×10^4
2	56.2	2(5-10 min)	3.2
3	43.5	3(10-15 min)	0
4	16.2	4(15-20 min)	0
5	16.1		
6	13.0		

* Temperature 75°F, 2° lapse; relative humidity 82%.
** Temperature 79°F, 2° lapse; relative humidity 49%.

b. Test Runs. In view of their operating conditions and functions, the vans were tested as follows to see what the effect on the degree of protection offered by the vans would be:

(1) While vents were closed and ventilating systems were off.

(2) While vents were closed and ventilating systems were recirculating air.

(3) While vents were open and ventilating systems were off.

(4) While vents were open and ventilating systems were on drawing outside air to check the pressurizing capability of the ventilating system.

(5) With vans field expedient sealed.

(6) With vans in expanded position at the start of an attack, then closed during attack (Figs. 9, 10, 11, and 12).

To determine leakage into the van bodies, six vacuum pump samplers were placed (in a hexagonal pattern) outside and around the vans, four samplers were placed between the vans, and two samplers were placed within each van (Fig. 13). These vacuum pumps, attached by rubber hose to the filter holders, drew air through the Millipore filters at a rate of approximately ten liters per minute, impinging the FP material on the filters. To determine concentration, the number of FP particles on each filter was counted, and the ratio of inside-to-outside concentration was taken to determine the extent of leakage.

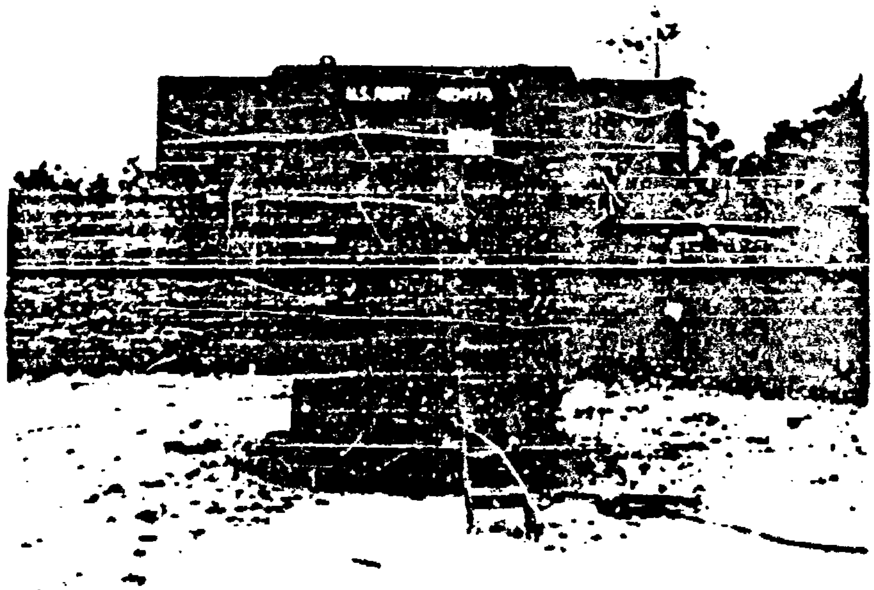

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Fig. 9. Engineer expansible van expanded.

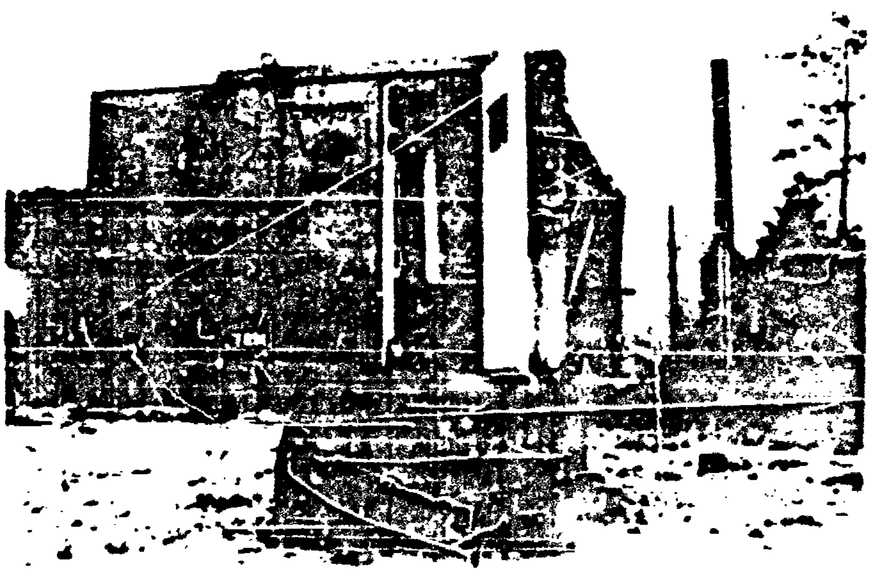

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Fig. 10. Engineer expansible van partially expanded.

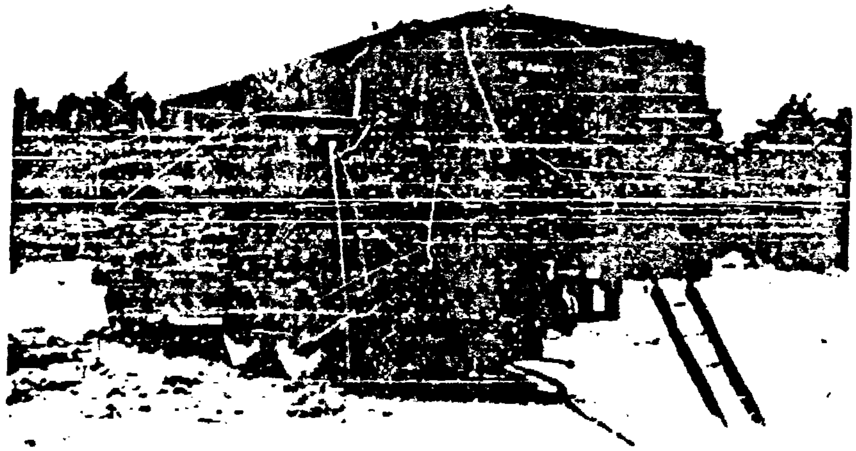

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Fig. 11. Camera van expanded.

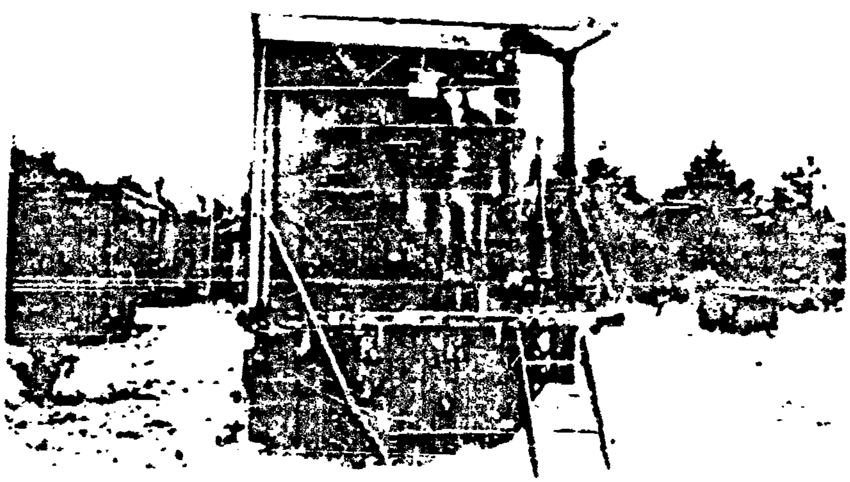

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Fig. 12. Camera van partially expanded.

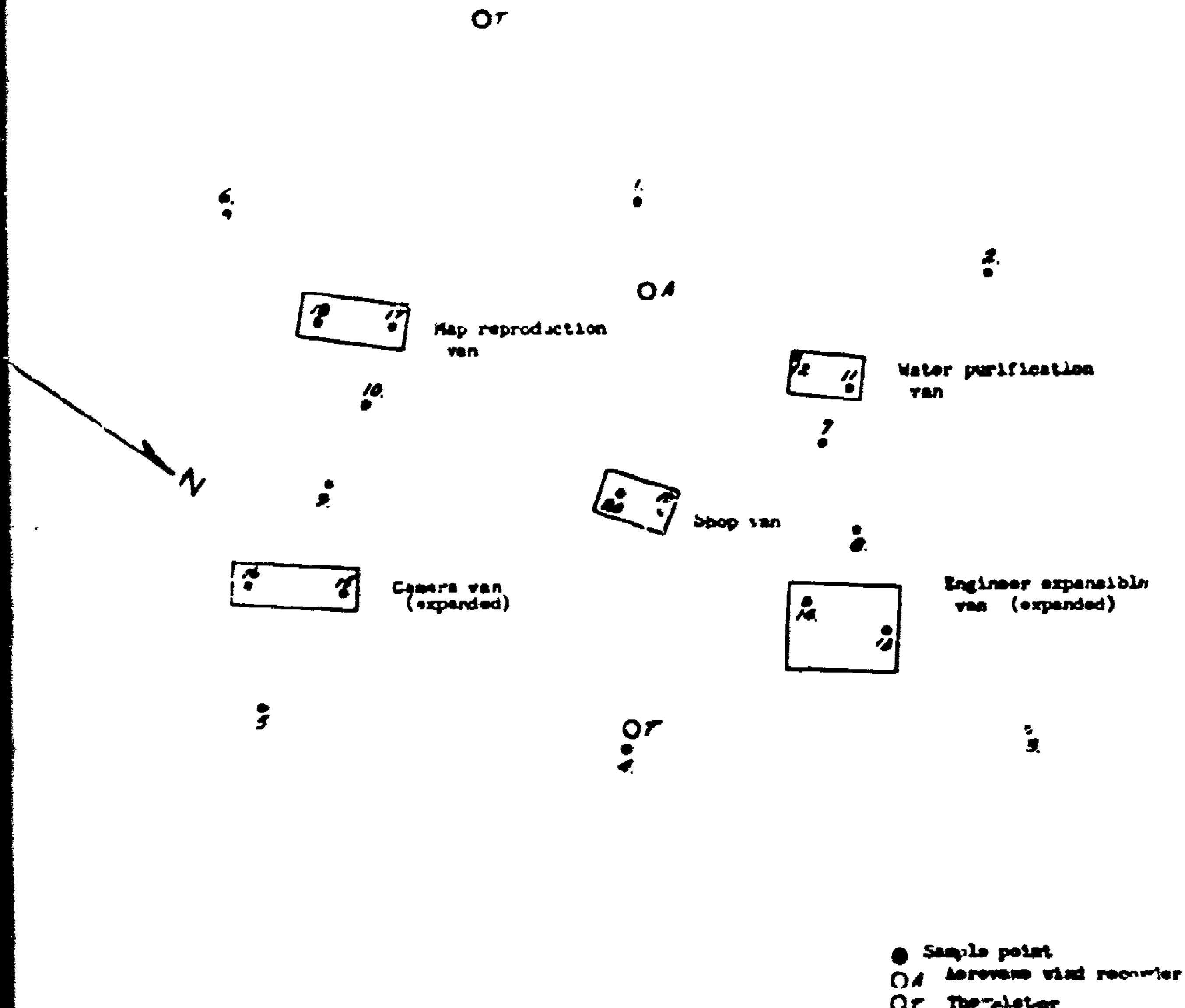

Fig. 13. Layout of the test area.

Electrical generators were started at the beginning of each run, and all meteorological instruments were turned on. Readings of wind velocity, relative humidity, barometric pressure, and temperature gradient were taken. Smoke grenades and helium-filled balloons were used to determine air currents. The balloons were weighted to float at a height of 6 to 10 feet. After the wind direction had been determined, the FP generator was set approximately 200 feet upwind from the center of the field and filter holders with clean filters were placed in position. All sampling pumps and the FP generator were started simultaneously at the beginning of the generation period. The aerovane systems were also turned on high speed (3 inches/min) at this time.

The FP generator was stopped at the end of the generation period, and the aerovane systems were turned on low speed (3 inches/hr). Ten minutes later, the outside sampling pumps were turned off and the filter holders were covered and collected. From 90 to 120 minutes later, the inside sampling pumps were turned off and the filter holders were covered and collected. All meteorological instruments were turned off at the same time as the inside sampling pumps. Wind charts, temperature gradient records, hygrothermograph charts, and readings of barometric pressure were collected and stored to be analyzed later. Test run data is contained in Appendix A.

c. Counting and Adjusting Counts. Counting the number of particles on each filter was accomplished with a microscope and two ultraviolet lamps (Fig. 14). The filters were glued with rubber

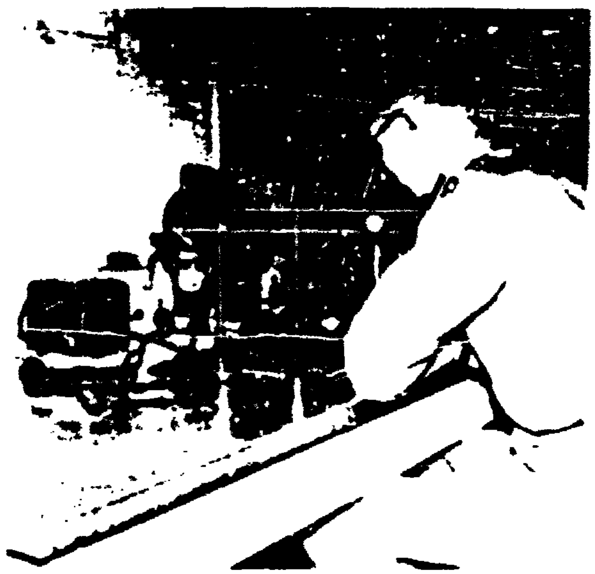

Fig. 14. Equipment shown: (l to r) GE transformer, powerstat variable transformer, ultraviolet lamps, and microscope.

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cement to microscope slides with uncontaminated surfaces of the filters next to the glass. By using reticles of known size, it was necessary to count only a relatively small number of particles. The number of particles actually counted was then multiplied by an area-ratio factor which is the ratio of the area seen through the reticle to the total area of the filter surface. Heavily contaminated surfaces were evaluated by counting ten or more random fields until a minimum of 270 particles was counted. A traversing technique which included one-half of the total filter surface was used for less contaminated surfaces (Fig. 15).

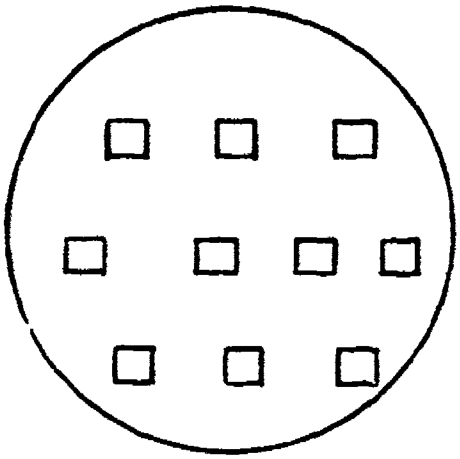

Fig. 15a. Representation of a filter surface showing random fields in which particles would be counted.

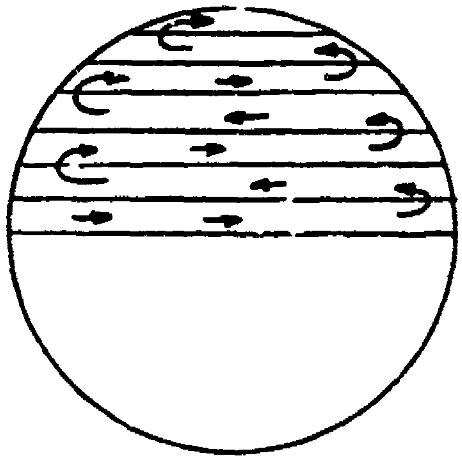

Fig. 15b. Representation of a filter surface showing traversing method of counting. The FP are counted as the filter is moved in the direction indicated by the arrows.

In order to correlate directly the different runs, the original FP counts were adjusted to an FP dispersion of 40 grams per run and a sampling pump flow rate of 10 liters per minute, using previously determined factors.

d. Determining Concentration. Leakage is the ratio of outside concentration to average concentration inside the van. The following method was used in approximating outside concentration around each van:

The average wind direction during each FP generation period was determined from the aerovane records and the observed paths of smoke and balloons. A wind direction line was then drawn from the generation point through the field. Four assumptions, based on knowledge of FP cloud behavior, were then made: (1) that the FP cloud was tear shaped; (2) that at any given distance from the generation point, the greatest FP concentration would be found on the wind direction line; (3) that concentration decreased as distance from the generation point increased; and (4) that any point between two points of known concentration would have a concentration lying between that of the two known points. Other points were plotted and assigned concentration values proportional to their position. Points of equal concentration were then connected with contour lines. Concentrations outside the vans were then approximated using the concentration of the nearest contour. It is believed that the concentration of a point can be determined within 20 percent of the true value. This makes allowance for the dropping out of highly inconsistent data points on the part of the person drawing the contours and for human error in counting. Inside concentration was taken as the average of the two inside samples. Figure 16 is a typical contour plot for determining FP concentration.

e. Leakage Values. Leakage values were computed by taking the ratio of inside concentration to outside concentration. These values, given in Table II, show the percentage of outside concentration which leaked into the vans.

Table II. Leakage Values (Percent)

Trial	Water Purification	Engineer Expansible	Camera	Map	Shop
A	29.4	30.1	32.0	52.6	35.4
B	57.5	57.6	57.6	81.5	46.4
C	38.5	50.0	43.6	-	30.6
D	7.9	15.9	-	-	16.0
E	24.0	28.8	-	-	52.8
F	32.8	40.7	-	-	17.0
G	34.1	36.8	25.8	-	29.1
H	-	5.3	1.0	-	14.0
I	-	10.0	16.0	9.1	69.7
J	-	23.2	26.9	2.6	63.7
L	-	17.6	-	-	-
M	-	39.6	28.0	-	-
N	33.2	42.8	49.2	26.0	93.0
O	12.7	10.1	40.4	40.6	25.1
P	23.5	97.7	41.7	42.3	26.0
Q	58.0	33.9	48.1	60.2	93.0
R	-	86.4	8.0	-	-

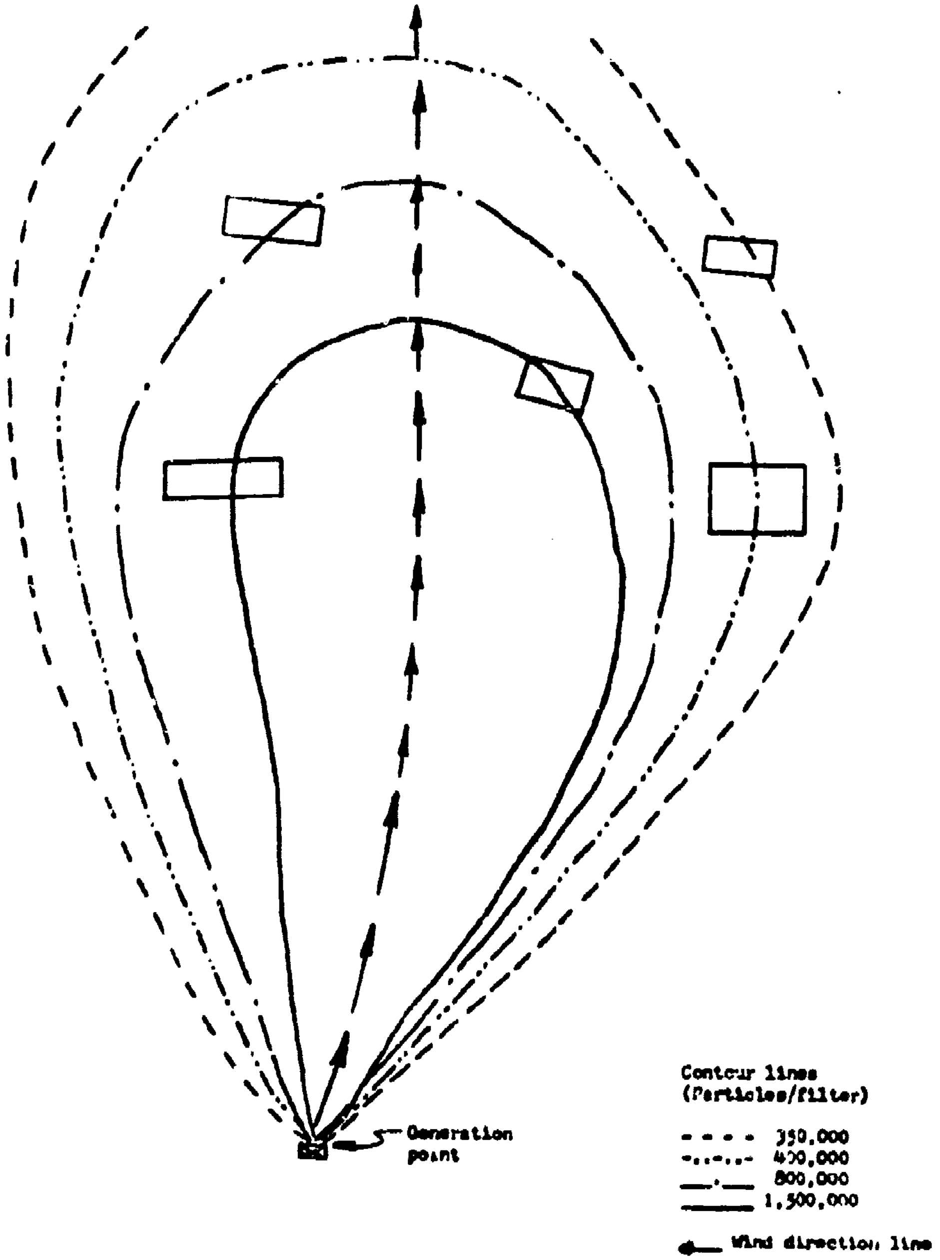

Fig. 16. Contour plot for Run A.

5. Pressurization. Pressurization of the vans by use of the ventilating systems was attempted during three runs. Transducers were used to record pressure changes. One run was made with the ventilating systems recirculating air, and negligible pressures were recorded as was expected. The two other runs were made with the ventilating systems drawing outside air. Significant pressures were recorded during these runs in the map reproduction and camera vans. Negligible pressures, probably caused by air escaping through open heater outlets, were recorded in the water purification and engineer expansible vans.

It has been determined in previous work[6] that the pressure differential that must be maintained to prevent leakage into a building should be 0.192 inch of water (0.036 psi) above the average pressure on the outside wall.

6. Correlation to CBR. The following paragraphs discuss the correlation of FP counts to the determination of CW, BW, and RW agents.

a. Chemical Warfare (CW). To arrive at the equivalent CW agent dosages, the FP counts were treated in the following manner:

Let the FP count represent dosage in particle minutes per liter. Dosage can be expressed as total particles, or as a product of the concentration times the time (particle-minutes/liter). Since there are 10^{12} particles per 40 grams of FP material, it can then be said that a given count of, for instance, 200,000 is:

200,000 particle-minutes/liter/10^{12} particles. Substituting micro grams (μg) for particles:

200,000 μg minutes/liter/10^{12} μg, but 10^{12} $\mu g = 10^6$ g = 1000 Kg.

Dividing by 1000:

200 μg min/liter/Kg

but $\mu g/l = mg/m^3$

or 200 mg min/m^3/Kg

This represents a chemical agent dosage of 200 mg min/m^3 for each kilogram of agent dispersed.

The dosages received inside the vans are considered incapacitating for most CW (HD, HN, L, MD) agents and lethal dosages for G and V agents. It should also be kept in mind that dosages in these tests were small, comparable to the detonation of one 2.2-pound chemical bomblet. Dosages many times those obtained in these tests can be attained in the field with conventional CW munitions. Since the dosages received inside the vans were very high when compared with outside dosages, it is concluded that LD_{50} dosages of all CW agents would penetrate the vans. Table III gives the calculated dosages received inside the vans, and Table IV compares dosages of a few typical CW agents.

Table III. Chemical Agent Dosages ($mg\ min/m^3/Kg$) Inside Vans

Trial	Water Purification	Engineer Expansible	Camera	Map	Shop
A	103	181	481	421	531
B	230	288	815	760	418
C	231	225	109	-	138
D	95	319	-	-	241
E	144	130	-	-	486
F	82	285	-	-	63
G	205	368	129	-	262
H	-	8	2	-	28
I	-	181	160	73	1046
J	-	406	1279	59	1435
L	-	442	-	-	-
M	-	992	336	-	-
N	399	835	122	78	1395
O	102	152	708	406	440
P	376	2199	1669	847	391
Q	38	679	289	722	2792
R	-	864	72	-	-

Table IV. Comparison of Dosages of Typical CW Agents

CW Agent	Dosage ($mg\ min/m^3$) LD_{50}	Incapacitating
CG	3,200	1,600
HD	1,500	200 by eye
GB	200	50
V	<GB	<GB

It is significant that FP dosages inside the vans were above 200 $mg\ min/m^3$ over 60 percent of the time.

Since some gases (CG, CK) are corrosive to metals, decontamination must take place within a very short time following attack by these agents in order to keep damage at a minimum. In addition, persistent agents would be hazardous to operating personnel. Operation of the vans would be unable to proceed before decontamination.

b. Biological Warfare (BW). The FP counts correlate directly to BW agent dosages, since infectious dosages depend only on the number of organisms contacted.

"Infectious" dosages of most BW agents were received in all trials. The lethal dosage for anthrax is estimated at 20,000 organisms by the respiratory route. For tularemia, 840 organisms are the estimated infectious respiratory dosage. In virtually all trials, the occupants of the vans received greater than a lethal dose for anthrax (see Table V), and the dosage received was above that for tularemia in all cases. It is apparent that infectious dosages would have been received from any BW agent which can be transmitted by aerosols.

Since BW agents may survive for some time, decontamination would be necessary in order to eliminate or reduce the hazard to personnel. The extent of decontamination necessary would vary with the type of agent and level of contamination.

Table V. BW Dosages Inside Vans Tested (Organisms)

Trial	Water Purification	Engineer Expansible	Camera	Map	Shop
A	103,000	181,000	481,000	421,000	531,000
B	230,000	288,000	815,000	760,000	418,000
C	231,000	225,000	109,000	-	138,000
D	95,000	319,000	-	-	241,000
E	144,000	130,000	-	-	486,000
F	82,000	285,000	-	-	68,000
G	205,000	368,000	129,000	-	262,000
H	-	8,000	2,000	-	28,000
I	-	181,000	160,000	73,000	1,046,000
J	-	406,000	1,279,000	59,000	1,435,000
L	-	442,000	-	-	-
M	-	992,000	336,000	-	-
N	399,000	835,000	122,000	78,000	1,395,000
O	102,000	152,000	708,000	406,000	440,000
P	376,000	2,199,000	1,669,000	947,000	391,000
Q	923,000	679,000	289,000	722,000	2,792,000
R	-	864,000	72,000	-	-

c. Radiological Warfare (RW)*. In order to correlate the FP trials to radioactive fallout, the areas in which 5,000,000 or more particles per filter were recovered were measured. This area averaged about 15,000 square yards. A fallout of 40 grams per 15,000 square yards is equivalent to a contamination of 2.7×10^{-4} grams per square yard. Since fission product fallout of 20 grams per square yard over an infinite area gives a dose-rate of approximately 1000 r/hr at H + 1 hour, a fallout of 2.7×10^{-4} grams per square yard over an infinite area will give a dose-rate of 0.13 r/hr at H + 1 hour. This dose-rate will result in a total dose of 0.62r from H + 1 hr to H + 10 weeks, a dosage far below the accepted AEC peacetime level. However, actual fallout near a nuclear detonation would approach a dose-rate of 1000 r/hr at H + 1 hr, resulting in a 10-day dosage of about 3500r. A lead or steel shield with a thickness many times the thickness of the van wall would be needed to effectively protect personnel from gamma radiation from fallout outside the vans. Decontamination of the area or removal of the vans to a clean area would be necessary under these high contamination levels to adequately protect operating personnel from external radiation. Decontamination of the vans would be necessary to remove fallout which might have leaked into the vans creating an inhalation hazard to personnel.

It has been found by tests at operation PLUMBBOB that the photographic film used in topographic units is relatively insensitive to gamma radiation. Experience by film manufacturers indicates that incorporation of alpha or beta emitters into film or developers will, because of the close proximity of the emitters and their ionizing potential, readily fog film. It appears that complete decontamination of vans in which films are processed would be necessary to protect film stocks.

III. DISCUSSION

7. Parameters. Comparing leakage values of the different trials gives a basis for stating that neither wind speed nor temperature gradient have much, if any, effect on leakage into the vans. Leakage values of trials "H" and "I" are somewhat lower than values for the other trials. This seems to show that sealing the vans by using masking tape, cardboard, or other field-expedient means was of limited usefulness in reducing leakage. The leakage reduction caused by field-expedient sealing was not great enough to give added protection from BW or newer CW agents, but limited protection from low concentrations of older CW agents can be obtained by sealing.

* RW is used here in the sense of radioactive fallout created by an atomic detonation.

Closing any expanded vans at the onset of an attack seems to have no effect on leakage. With actual CW or BW agents, the attack may be well under way or even ended before the agent is detected. Since no apparent additional protection is afforded by closing the vans, they may remain expanded unless they are to be moved from the area.

IV. CONCLUSIONS

8. Conclusions. It is concluded that:

a. The vans offer little or no protection against newer CW agents and only limited protection against older CW agents.

b. Decontamination of the vans following a CW attack would be necessary to keep damage at a minimum and to remove any hazard to operating personnel.

c. None of the vans offer protection against BW agents.

d. Decontamination of the vans following a BW attack would be necessary to eliminate or reduce the hazard to personnel.

e. The vans offer negligible protection from radiation from fallout outside the vans.

f. Decontamination of the vans following an RW attack would be necessary to remove any inhalation hazard resulting from fallout which might leak into the vans.

g. Decontamination of vans in which films are processed would be necessary to protect film stocks.

h. Field expedient sealing is of little value; limited protection against older CW agents, however, can be obtained by its use.

i. The present ventilation system is able to cause significant pressurization of the vans.

j. Minor modification of the ventilation system by the addition of a gas-particulate filter combined with additional sealing around openings will probably provide adequate gas-proofing for the vans.

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APPENDIX

TEST RUN DATA

Run A

Date and time: 26 Sep 56, 1030 Wind speed and direction: 6 mph, NE

Relative Humidity: 80% Barometer: 29.9 in. Temperature: 58.2°, 0.5° inversion

F.P. Released: 42.2 gms Cloud cover: 75% Visibility: Good

Conditions: Ventilation systems off. Vents open. Doors and windows closed. Camera van and engineer expansible van expanded.

Generated: 30 minutes Samples run: Outside 40 minutes Inside 120 minutes

Sample Point	Raw Count	Count Adjusted*
1	45.6×10^4	43.2×10^4
2	11.1	10.5
3	14.0	13.3
4	214.9	207.7
5	121.1	114.8
6	58.0	55.0
7	45.2	42.8
8	37.2	35.3
9	153.4	145.4
10	104.9	99.4
11	11.2	10.6
12	10.4	9.9
13	20.1	19.0
14	18.3	17.3
15	54.2	51.4
16	47.4	44.9
17	43.1	40.9
18	45.7	43.3
19	63.1	59.8
20	49.0	46.4

* Corrected to 10 liter/minute air flow and 40 gram source.

Run B

Date and time: 2 Oct 56, 1030 Wind speed and direction: 4 mph, SW

Relative humidity: 84-60% Barometer: 29.8 in. Temperature: 64°, 2° inversion

F.P. Released: 34.8 gms Cloud cover: 50% Visibility: Fair

Conditions: All ventilation systems off. Vents open. Lights on. Doors and windows closed. Blackout covers in place. Camera van and engineer expansible van expanded.

Generated: 30 minutes Samples run: Outside 40 minutes Inside 120 minutes

Sample Point	Raw Count	Count Adjusted
1	39.3×10^4	45.1×10^4
2	15.9	18.3
3	25.7	29.5
4	54.4	62.5
5	72.1	82.8
6	134.5	154.5
7	33.0	37.9
8	45.4	50.0
9	69.9	80.3
10	112.1	128.8
11	20.2	23.2
12	19.9	22.8
13	27.4	31.4
14	23.2	26.6
15	71.3	81.9
16	70.7	81.2
17	66.4	76.3
18	66.0	75.8
19	30.1	34.5
20	42.9	49.2

Run C

Date and time: 3 Oct 56, 1400 Wind speed and direction: 2 mph, SW-NW

Relative humidity: 39% Barometer: 29.8 in. Temperature: 75.5°, 4° lapse

F.P. Released: 40.[illegible] gms Cloud cover: 50% Visibility: Excellent

Conditions: All ventilation systems off. Vents closed. Camera van and engineer expansible van expanded. Blackout covers in place.

		Outside	Inside
Generated: 30 minutes	Samples run:	40 minutes	120 minutes

Sample Point	Raw Count	Count Adjusted
1	41.2×10^4	40.8×10^4
2	54.1	53.6
3	30.2	29.9
4	19.6	19.4
5	22.6	22.4
6	35.4	35.1
7	57.6	57.1
8	56.2	55.7
9	27.6	27.3
10	33.2	32.9
11	23.7	23.5
12	23.1	22.9
13	22.2	22.0
14	23.3	23.1
15	11.8	11.7
16	10.2	10.1
17	3.3	3.2
18	0.3	0.2
19	14.0	13.8
20	14.0	13.8

Run D

Date and time: 5 Oct 56, 0900 Wind speed and direction: 4 mph, NE

Relative humidity: 83.5% Barometer: 30.0 in. Temperature: 63°, 1.3° lapse

F.P. Released: 41.6 gms Cloud cover: 75% Visibility: Good

Conditions: All ventilation systems off. Vents closed. Camera van and engineer expansible van expanded. Blackout covers in place.

Generated: 5 minutes Samples run: Outside 15 minutes Inside 90 minutes

Sample Point	Raw Count	Count Adjusted
1	71.3×10^4	68.5×10^4
2	74.6	71.6
3	180.0	172.9
4	241.9	232.4
5	40.3	38.7
6	39.2	37.6
7	153.5	147.5
8	168.2	161.6
9	69.2	66.5
10	52.0	49.9
11	11.8	11.3
12	8.2	7.8
13	35.8	34.4
14	30.6	29.4
*		
19	21.8	20.9
20	28.7	27.5

* Counts not taken for sample points 15-18.

Run E

Date and time: 8 Oct 56, 0900   Wind speed and direction: 3 mph, SW

Relative humidity: 58%   Barometer: 30.03 in.   Temperature: 65°, 4° lapse

F.P. Released: 48.6 gms   Cloud cover: 0%   Visibility: Excellent

Conditions: Ventilation systems off. Vents closed. Camera van and engineer expansible van expanded. Blackout covers in place.

		Outside	Inside
Generated: 5 minutes	Samples run:	15 minutes	90 minutes

Sample Point	Raw Count	Count Adjusted
1	162.2 x 10^4	133.4 x 10^4
2	17.2	14.1
3	4.5	3.7
4	57.6	47.4
5	56.4	46.4
6	17.7	14.5
7	75.8	62.3
8	65.6	53.9
9	51.2	42.1
10	104.6	86.0
11	18.6	15.3
12	16.5	13.5
13	14.9	12.2
14	16.8	13.8
*		
19	53.1	43.7
20	65.1	53.5

* Counts not taken for sample points 15-18.

Run F

Date and time: 10 Oct 56, 1100   Wind speed and direction: 4 mph, NE

Relative humidity: 51%   Barometer: 30.29 in.   Temperature: 60°, 2° lapse

F.P. Released: 44 5 gms   Cloud cover: 0%   Visibility: Excellent

Conditions: All ventilating systems were set to recirculate air within the vans and were run during the entire test. Transducers were used to record pressure changes. Camera van and engineer expansible van expanded.

Pressures (Psi):

Location	Peak	Average
Map van	+0.0010	-0.0012
Shop van	+0.0017	-0.0012
Water purification	+0.0050	+0.0012
Engineer expansible	+0.0045	+0.0010

Generated: 30 minutes   Samples run: Outside 40 minutes   Inside 120 minutes

Sample Point	Raw Count	Count Adjusted
1	29.1×10^4	26.1×10^4
2	45.8	41.1
3	114.3	102.7
4	51.5	46.2
5	24.0	21.5
6	20.0	17.9
7	38.3	34.4
8	50.0	44.9
9	26.9	24.1
10	27.1	24.3
11	11.0	9.8
12	7.4	6.6
13	33.7	30.2
14	30.0	26.9
*		
19	3.2	2.8
20	12.1	10.9

* Counts not taken for sample points 15-18.

Run G

Date and time: 12 Oct 56, 1030 Wind speed and direction: 5 mph, NNE

Relative humidity: 64-39% Barometer: 30.4 in. Temperature: 56°, 2° inversion

F.P. Released: 43.2 gms Cloud cover: 0% Visibility: Good

Conditions: All conditions same as for Run F.

Generated: 30 minutes* Samples run: Outside 45 minutes Inside 120 minutes

Sample Point	Raw Count	Count Adjusted
1	45.6×10^4	42.2×10^4
2	48.5	44.9
3	148.2	137.2
4	143.7	133.0
5	48.8	45.1
6	28.8	26.6
7	90.6	83.6
8	86.0	79.6
9	61.4	56.8
10	44.8	41.4
11	20.6	19.0
12	23.9	22.1
13	40.7	37.6
14	38.9	36.0
15	12.9	11.9
16	15.2	14.0
**		
19	29.5	27.3
20	27.2	25.1

* Generated 5' 15" from point NNE of field, then moved to point due E of field due to wind shift.
** Counts not taken for sample points 17 and 18.

Run H

Date and time: 15 Oct 56, 1000 Wind speed and direction: 0-1 mph, NE

Relative humidity: 30% Barometer: 30.2 in. Temperature: 62.5°, 1° lapse

F.P. Released: 25.5 gms Cloud cover: 0% Visibility: Good

Conditions: Engineer expansible, camera, and map reproduction vans were field expedient sealed with masking tape. All cracks, joints, and openings were sealed except for windows and 1 door of each van. Ventilators on the engineer expansible van were covered with cardboard and side vent covered on camera van. Shop van was expanded, and side curtains were put on and closed as tight as possible.

Generated: 31 minutes Samples run: Outside 40 minutes Inside 120 minutes

Sample Point	Raw Count	Count Adjusted
1	10.7×10^4	16.7×10^4
2	9.3	14.5
3	8.2	12.8
4	9.0	14.1
5	14.1	22.1
6	4.8	7.5
7	9.8	15.3
8	11.4	17.8
9	10.5	16.4
10	4.9	7.6
*		
13	0.4	0.6
14	0.7	1.0
15	0.2	0.3
16	0.1	0.1
**		
19	2.1	3.2
20	1.6	2.5

* Counts not taken for sample points 11 and 12.

** Counts not taken for sample points 17 and 18.

Run I

Date and time: 17 Oct 56, 0930 Wind speed and direction: 2 mph, N

Relative humidity: 78% Barometer: 30 in. Temperature: 64.5°, 0.5° inversion

F.P. Released: 42.0 gms Cloud cover: 100% Visibility: Good

Conditions: All conditions same as for Run H.

Generated: 30 minutes Samples run: Outside 40 minutes Inside 120 minutes

Sample Point	Raw Count	Count Adjusted
1	105.4×10^4	100.3×10^4
2	59.8	56.9
3	147.1	140.0
4	252.9	240.7
5	89.6	85.2
6	67.2	63.9
7	136.5	129.9
8	119.3	113.5
9	113.3	107.8
10	116.1	110.5
*		
13	18.6	17.7
14	19.8	18.8
15	11.9	11.3
16	21.8	20.7
17	9.8	9.3
18	5.6	5.3
19	111.1	105.7
20	108.9	103.6

* Counts not taken for sample points 11 and 12.

Run J

Date and time: 19 Oct 56, 0100   Wind speed and direction: 2 mph, N

Relative humidity: 98%   Barometer: 30 in.   Temperature: 57.5°, 2° inversion

F.P. Released: 41.6 gms   Cloud cover: 75%   Visibility: Good

Conditions: Expansible, camera and shop vans expanded.

Generated: 30 minutes   Samples run: Outside 40 minutes   Inside 120 minutes

Sample Point	Raw Count	Count Adjusted
1	56.7×10^4	92.9×10^4
2	23.4	22.4
3	41.2	39.5
4	108.1	103.8
5	520.8	500.4
6	201.1	193.2
7	108.1	103.8
8	156.8	150.8
9	433.4	416.4
10	276.8	266.0
*		
13	41.9	40.2
14	42.8	41.1
15	140.[illegible]	134.5
16	126.4	121.4
17	8.4	8.0
18	4.0	3.8
19	135.2	129.9
20	163.6	157.2

* Counts not taken for sample points 11 and 12.

Run K

Test results not retained for records due to weather difficulty.

Run L

Date and time: 24 Oct, 56, 0930 Wind speed and direction: 4 mph, NE

Relative humidity: 100% Barometer: 29.5 in. Temperature: 64.7°, 1.1° inversion

F.P. Released: 17.8 gms Cloud cover: 100% Visibility: Poor

Conditions: Expansible and camera vans were only ones tested. Vans in expanded position at start of run. After 5 minutes generation, vans were closed. Generation continued an additional 5 minutes following closing. (Time to close vans: camera, 25 seconds; expansible, 2 minutes 8 seconds.) Sampling time was limited to 13 minutes due to rain.

Generated: 12 minutes Samples run: Outside 13 minutes Inside 13 minutes

Sample Point	Raw Count	Count Adjusted
1	43.0×10^4	96.6×10^4
2	40.6	91.2
3	162.6	365.3
4	125.0	280.8
5	22.7	51.0
6	25.3	56.8
7	65.1	146.2
8	57.5	129.2
9	46.1	103.5
10	37.5	84.2
*		
13	21.4	48.0
14	18.0	40.4
15**	0.6	1.3
16**	0.8	1.7
***		

* Counts not taken for sample points 11 and 12.

** When count was taken, it was discovered that there was cigaret smoke in the camera van; runs, therefore, were not considered in results for camera van.

*** Counts not taken for sample points 17-20.

Run M

Date and time: 25 Oct 56, 0925 Wind speed and direction: 2 mph, N

Relative humidity: 68% Barometer: 30.36 in. Temperature: 49.5°, 1.0° lapse

F.P. Released: 61.5 gms Cloud cover: 0% Visibility: Excellent

Conditions: All conditions same as Run L. (Time to close vans: camera, 18 seconds; expansible, 2 minutes 30 seconds.)

Generated: 12.5 minutes Samples run: Outside 22.5 minutes Inside 22.5 minutes

Sample Point	Raw Count	Count Adjusted
1	195.6 x 10^4	127.1 x 10^4
2	114.9	74.6
3	40.1	26.0
4	632.2	410.9
5	132.2	85.9
6	176.7	114.8
7	240.0	156.0
8	318.2	206.8
9	244.3	158.7
10	383.9	249.5
*		
13	153.3	99.6
14	152.3	98.9
15	60.4	39.2
16	43.2	28.0
**		

* Counts not taken for sample points 11 and 12.
** Counts not taken for sample points 17-20.

Run N

Date and time: 29 Oct 56, 1000   Wind speed and direction: 0-2 mph, NE

Relative humidity: 94%   Barometer: 33 in.   Temperature: 55.5°, 0.6° lapse

F.P.Released: 47.8 gms   Cloud cover: 100%   Visibility: Poor

Conditions: All ventilating systems were set to draw outside air; blower fans, however, were not turned on. Shop van was only van in expanded. Very slight misty rain fell during test; outside samples, therefore, were taken upside down.

Generated: 30 minutes   Samples run: Outside 40 minutes   Inside 120 minutes

Sample Point	Raw Count	Count Adjusted
1	132.2×10^4	110.1×10^4
2	123.0	102.4
3	171.8	143.1
4	[illegible]	156.5
5	30.3	25.2
6	46.3	38.5
7	150.6	125.4
8	175.0	145.7
9	21.5	17.9
10	26.2	21.8
11	53.8	44.8
12	42.2	35.1
13	82.4	68.6
14	118.2	98.4
15	15.8	13.1
16	13.7	11.4
17	9.5	7.9
18	9.4	7.8
19	158.2	131.7
20	177.0	147.4

Run O

Date and time: 30 Oct, 1 Nov 56, 0915 Wind speed and direction: 2 mph, N

Relative humidity: 97% Barometer: 29.9 in. Temperature: 64.1°, 1.5° inversion

F.P. Released: 37.2 gms Cloud cover: 100% Visibility: poor, foggy

Conditions: All ventilating systems were set to draw outside air and turned on. Transducer 165 was transferred from shop van to camera van. (See Run F.)

Pressures (psi):

Location	Peak	Average
Map van	0.0620	0.054
Camera van	0.0170	0.012
Water Purification	0.0030	0.0024
Engineer expansible	0.0020	0.0002

Generated: 28 minutes Samples run: Outside 30 minutes Inside 30 minutes

Sample Point	Raw Count	Count Adjusted
1	32.7×10^4	35.1×10^4
2	17.9	19.2
3	46.9	50.4
4	276.1	296.8
5	143.8	154.5
6	54.8	58.9
7	90.7	97.5
8	90.2	96.9
9	160.2	172.2
10	116.5	125.2
11	10.0	10.7
12	9.1	9.7
13	16.7	17.9
14	11.7	12.5
15	54.2	58.2
16	77.7	83.5
17	38.7	41.6
18	36.9	39.6
19	44.1	47.4
20	37.8	40.6

Run P

Date and time: 2 Nov 56, 0930   Wind speed and direction: 0-1 mph, ESE

Relative humidity: 98%   Barometer: 29.9 in.   Temperature: 65°, 0.3° inversion

F.P. Released: 33.1 gms   Cloud cover: 100%   Visibility: poor, foggy

Conditions: Repeat of Run O. Due to shifting wind, generator was mounted on back of 3/4-ton truck. Truck was driven in a semi-circular arc during generation. Arc was from NE to SW (180°).

Generated: 25 minutes   Samples run: Outside 35 minutes   Inside 60 minutes

Sample Point	Raw Count	Count Adjusted
1	59.3×10^4	71.6×10^4
2	94.3	113.9
3	211.8	255.8
4	156.3	188.8
5	347.0	419.1
6	344.4	416.0
7	109.8	132.6
8	145.5	175.7
9	217.5	262.7
10	187.4	226.3
11	33.1	39.9
12	29.3	35.3
13	172.2	208.0
14	192.0	231.9
15	139.8	168.8
16	136.7	165.1
17	70.1	84.6
18	70.2	84.8
19	35.5	42.8
20	29.4	35.5

Run Q

Date and time: 5 Nov 56, 1000 Wind speed and direction: 5 mph, NE

Relative humidity: 76% Barometer: 31.5 in. Temperature: 62.5°, 1.5° lapse

F.P. Released: 51.1 gms Cloud cover: 75% Visibility: Fair

Conditions: A repeat of Run O.

Pressures (psi):

Location	Average
Map van	0.0400
Camera van	0.0130
Water purification	0.0009
Engineer expansible	-0.0054

Generated: 30 minutes Samples run: Outside 40 minutes Inside 60 minutes

Sample Point	Raw Count	Count Adjusted
1	103.2×10^4	80.7×10^4
2	130.2	101.9
3	161.5	126.4
4	344.3	269.5
5	18.5	14.4
6	23.6	18.4
7	231.4	181.1
8	240.9	188.6
9	35.4	27.7
10	89.7	70.2
11	122.7	96.0
12	113.2	88.6
13	110.3	86.3
14	63.4	49.6
15	25.9	20.2
16	50.7	39.6
17	90.2	70.6
18	94.3	73.8
19	237.5	185.9
20	220.5	172.6

Run R

Date and time: 6 Nov 56, 0900   Wind speed and direction: 0-2 mph, S

Relative humidity: 30%   Barometer: 30 in.   Temperature: 54.0°, 0.2° inversion

F.P. Released: 41.3 gms   Cloud cover: 0%   Visibility: Excellent

Conditions: Only engineer expansible and camera vans tested. Vents closed, ventilation systems off. Vans not expanded. Only one sample taken in each van.

Generated: 30 minutes   Samples run: Outside 40 minutes   Inside 60 minutes

Sample Point	Raw Count	Count Adjusted
1	174.4×10^4	168.1×10^4
2	118.6	114.3
3	71.9	69.3
4	76.6	73.8
5	90.7	87.4
6	290.8	280.3
7	136.0	131.1
8	104.7	100.9
9	96.6	93.1
10	174.7	168.4
*	89.7	86.4
**	7.5	7.2

* Engineer expansible van.

** Camera van.

Special Category

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